Estimating misalignment in Irish commercial property prices

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Non-Technical Summary

Boom and bust conditions feature regularly in the real estate market often with significant real effects. The Irish financial crisis is a recent example of the adverse impact of the unwinding of a leveraged commercial property boom. The estimation of Irish commercial property prices has received relatively less attention in the literature compared with house prices. To address this gap and further the systemic risk assessment of this sector, this paper examines the dynamic behaviour of Irish commercial property prices.

Using economic theory, a reduced-form econometric model is first specified. Demand-side influences such as income and interest rates are found to play a significant role in determining price movements between 1985 and 2012. However, the model also shows periods over the sample where commercial property prices persistently deviate from fundamentally-determined prices. Given the role credit played in the Irish economy in the last 20 years, a second approach (Autoregressive Distributed Lag (ARDL)) is also used to address this effect in particular. Under this approach, credit is found to have had a positive effect on commercial property prices.

As a compliment to the econometric approach, and in particular due to the difficulty in correctly approximating a fundamental price, two simpler approaches of measuring misalignment in commercial property prices are also developed. These approaches are based loosely on the concept of excessive price growth. Such approaches are currently being considered in the macro-prudential policy debate in the context of potentially useful indicators of systemic instability. In general, the various measures of misalignment show a broadly consistent picture. A period of positive misalignment is evident in Irish commercial property prices in the early 1990s and again through the 2000s in the build-up to the crisis. The results suggest undervaluation in the mid-1990s as well as during the crisis itself.

Borrowing from the stock price literature we investigate the nature of the estimated misalignment and test whether Irish real commercial property prices conform to the irrational fads hypothesis or the rational collapsing bubble theory over the sample period. These models attempt to explain the non-fundamental component of prices that can be attributed to investor behaviour over the property cycle. In both cases, the collective action of investors leads to price spirals and periods where market prices rise above fundamentals. A better understanding of the dynamics of this market will help the modelling and forecasting of prices. Results suggest that a rational bubbles hypothesis might explain real commercial property prices over the sample period. However we cannot make a definitive conclusion as the results do not support all of the implications of the bubble model.

Indicators of misalignment in commercial property prices are now being looked at internationally as useful in terms of the practical implementation of macro-prudential policy. Macro-prudential policy and the identification of systemic risk have gained added prominence in recent years with the monitoring of real estate risks and the identification of property price misalignment a high priority for policy-makers. The measures outlined in this paper should add to the financial stability analysis of the Irish commercial real estate market and may be useful in macro-prudential policy discussions for the sector.

Estimating misalignment in Irish commercial property prices [1]

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Abstract

This paper analyses price dynamics in the Irish commercial real estate market over the period 1985 to 2012, using a variety of statistical approaches. Testing if prices can be explained by economic fundamental determinants such as income, interest rates and credit, we find evidence of some deviations between actual and fundamental prices over the sample period. In addition, using two popular models of price misalignment from the stock price literature, we test whether estimated misalignments between actual prices and fundamentals (i.e., non-fundamental prices) suggest that there was an irrational fad or a rational bubble in Irish commercial property prices during the period under study. To distinguish between these two models, regime switching methodology is used. The data show some evidence of a rational bubble over the period under study although the results are not conclusive. From a policy perspective, macro-prudential policy and the identification of systemic risk have gained prominence following the recent global crisis. In addition to credit dynamics, real estate risks and the identification of property price misalignment remains a high priority for policy-makers. As such the analysis and indicators developed here could be used to inform a systemic risk assessment of the commercial real estate market in Ireland.

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1 Introduction

Boom and bust conditions feature regularly in real estate markets, often with significant real effects. This is especially the case if property investment is highly leveraged. However, even if a real estate boom or bubble is not accompanied by rapid credit growth, its reversal can have real effects. Investment may flow into this market to gain a high return, creating a potential misallocation of economic resources and affecting the price of other assets (Blanchard and Watson, 1982). While movements in house prices garner relatively more attention due to the potential wealth effects for households, commercial property prices also merit attention given the market's key role in both the origin and propagation of many financial crises. Historical examples regularly cited are the Savings and Loan crisis in the United States in the late-1980s, the Nordic crisis in the 1990s, the East Asian and the Japanese crisis of the 2000s (Herring and Wachter, 1999 & ECB, 2008).

The Irish financial crisis is a recent example of the adverse impact of commercial property prices. Real Irish commercial property prices increased by circa 200 per cent between 1995 and mid-2007 with bank credit the funding of choice for many investors. This was a period of rapid economic growth for the Ireland with GDP per capita converging on our European counterparts[4] and borrowing costs declining in line with policy rates, a reduction in perceived risk and increased access to cheaper European funding markets. The combination of favourable demand conditions and an increased willingness to supply credit boosted the commercial property market in Ireland. Simple indicators of price misalignment such as the price-rent ratio or its inverse, the property yield appeared to have decoupled from their respective historical average during this time. The Irish housing market also followed a similar pattern. By end-2012, however, commercial property prices had fallen by almost 70 per cent from their peak in 2007 with many Irish banks facing losses on their property exposures. During the crisis, market liquidity evaporated and investor sentiment became increasingly negative towards property-related assets. While the global financial crisis provided the external shock, vulnerabilities within the domestic banking system such as imprudent lending and skewed balance sheets led to a costly systemic crisis.[5] The misallocation of real resources up to 2007, with aggregate investment heavily dependent on property also rendered domestic demand vulnerable to such shocks. While adjustments in both residential and commercial property markets caused problems for the banks, the initial phases of the crisis (i.e., 2008-2010) saw sharper price deflation and relatively higher declines in the quality of the commercial portfolios with a subsequent impact on profitability.[6]

The Irish case and other historical examples highlight the importance of early detection of unsustainable commercial property price developments, particularly if investors are highly leveraged. Following the global crisis as the macro-prudential policy toolkit to address sectoral systemic risk concerns has increased[7] the development

[4] See Honohan and Walsh, 2002.

[5] See Honohan (2010) and Regling and Watson (2010) for details on the origins of the Irish crisis.

[6] The Irish Government established the National Asset Management Agency (NAMA) in 2010 to remove problem commercial property loans from domestic banks' balance sheets.

[7] For example work at operationalizing the counter-cyclical capital buffer has analysed the usefulness of a large number of variables as indicators of financial crisis (ESRB, 2014).

of indicators to aid the systemic risk assessment of property markets is underway (see Giese *et al.*,2012 and ESRB, 2014). This paper aims to contribute to this research drawing on the Irish experience.

The estimation of Irish commercial property prices has received relatively less attention in the literature compared with house prices. There are a number of published papers on supply and rent dynamics in the Dublin office market (McCartney, 2008, 2011) and on land prices (Browne and Fagan, 1992, & Roche and McQuinn, 2000). International commercial property markets have been the subject of a number of papers such as Hendershott (2000) on the Sydney office market, Chervachidze and Wheaton (2013) on cap rates in the United States and Ball and Grilli (1996) on commercial property investment in the United Kingdom to name but a few. Commercial property prices have also featured in cross-country studies such as Davis and Zhu (2011) who examine the link between bank lending and price determination and in Hendershott *et al.*, (2005) who review tests for market rationality in a number of countries.

To address the perceived gap in the Irish literature this paper examines the dynamic behaviour of Irish commercial property prices. We first specify a reduced-form econometric model using economic fundamentals to explain movements in commercial property prices. While income and interest rates are found to play a significant role in determining price movements we find periods over the sample where commercial property prices persistently deviate from fundamentally-determined prices. Given the nature of the Irish experience we also analyse the role of credit in explaining commercial property prices. Using this approach, pre-crisis (i.e., up to 2007) misalignments in Irish commercial property prices are also evident. Due to the difficulty in correctly approximating a fundamental price and as a complement to the econometric approach, we also use two simpler approaches to looking at misalignment in commercial property prices based roughly on the concept of excessive price growth. In general, the various measures show a consistent picture. A period of positive misalignment is evident in Irish commercial property prices in the early 1990s and consistently throughout the 2000s in the build-up to the crisis. The results suggest undervaluation in the mid-1990s as well as in the crisis period.

To gain a better understanding of the nature of the misalignment or non-fundamental component of prices, the paper further tests if there is evidence of an irrational fad or a rational stochastic bubble in Irish commercial property prices over the period under study. Such models have been used in the stock market literature to explain why equity prices vary relative to their intrinsic value based on theoretically justified determinants (e.g., Schiller, 1984, Cutler, Poterba and Summers, 1991 and Blanchard and Watson, 1982). The underlying theory and methodology from this literature are deemed applicable to commercial property given its role as an important investment asset. Although it may not matter from a policy perspective whether prices follow a fad or a rational bubble as misalignment occurs in either case, a deeper understanding of commercial property price dynamics helps to model and forecast prices more efficiently. If Irish commercial property prices are subject to faddish behaviour, the deviation between actual and fundamental prices should have some explanatory power for future prices changes. As the deviation is assumed to be temporary, an increasing gap or price misalignment should lead to a decrease in price returns. Herding behaviour among investors may be one possible explanation for the existence of fads in the data. The

stochastic bubble theory assumes that if a bubble exists, investors incorporate this into their valuations for current prices. As the probability of a bubble surviving increases, investors demand higher returns to compensate for the potential losses when a crash eventually occurs. Bubbles are thus the outcome of self-fulfilling expectations about future prices. According to the rational bubble theory, prices are expected to behave differently depending on whether they are in a bubble or non-bubble phase. With both fads and bubbles, the collective action of investors leads to price spirals and periods where market prices rise above fundamentals.

The paper draws on an empirical approach by Schaller(1996) and Schaller and Van Norden (2002) which allows us to test between a fad and a bubble using regime switching techniques. The framework nests the fad specification within a general rational bubble equation so that by testing the validity of the restrictions associated with the presence of a fad, we can infer which model best fits the data. This approach is applied to Irish house prices and Irish agricultural land prices in Roche (1999) and Roche and McQuinn (2000), respectively. There are some differences in the empirical approach undertaken in this paper. Schaller and Van Norden use simple switching techniques while our paper uses Markov switching methodology to capture persistence. We also use time-invariant transition probabilities rather than imposing the assumption that the size of the misalignment governs the switch between regimes. Based on the Irish experience, we prefer to allow the possibility that exogenous factors such as an expectations shock or news may also generate the switch between regimes. We generally reject the restrictions imposed by the fads model in favour of a bubble, although the theoretical features of the bubble specification are not fully supported across our estimates of misalignment or non-fundamental price.

The paper is structured into the following sections. Section 2 discusses the analytical underpinnings and associated literature for the empirical approach. In section 3, we outline the data used in the paper. Section 4 estimates two reduced-form models of Irish commercial property prices while section 5 outlines two simpler approaches to detecting misalignment in prices. Section 6 tests if rational bubble or fad hypotheses apply to the Irish market. A summary and the main conclusions are contained in the final section.

2 Literature and overview of analytical approach

To explain the dynamics of Irish commercial property prices, we draw on a number of different strands of the real estate and asset-pricing literature. We are primarily interested in estimating the fundamental commercial property price for the Irish market and identifying periods when actual prices may have deviated from this value over the sample. Accordingly we use the real estate literature to guide our approach. Extending the analysis further, we would also like to explain why such deviations occurred. Therefore, we also draw on the equity price literature and specifically the approach for testing for bubble-like behaviour in prices using regime switching techniques. This section looks at each of these aspects in turn.

2.1 Commercial property price determination

As noted, the estimation of Irish commercial property prices has received relatively less attention in the literature compared with house prices. Given the shortage of Irish literature specifically on price determination[8], we look to international studies for guidance. Two popular approaches are testing the market for efficiency using empirical finance-based techniques or estimating a reduced form econometric model where the underlying economic determinants of prices are suggested by economic theory in a demand/supply framework. As noted by Hordahl and Packer, (2007), there are many challenges associated with the finance-based approach given that both the property-risk premium and expected future cash flows are unobservable and therefore must be estimated. To approximate a fundamental price, this paper, therefore, focuses on investigating the economic determinants using reduced form econometric approach.[9]

We follow the analytical framework of Davis and Zhu, (2004 & 2012, hereafter DZ). Using a theoretical model, commercial property cycles are shown to be influenced by two channels, namely exogenous shocks to the economic cycle and market-specific features over the cycle which can amplify the effects of macro-economic shocks leading to oversupply. In the DZ paper, commercial property prices are determined by a four equation system.

$$D_t \equiv \frac{N[1-F(P_t)]L(Y_t, i_t, P_t, \omega_t)}{P_t}, where L_y > 0, L_i < 0, L_p > 0 \tag{1}$$

$$K_t = (1-\delta)K_{t-1} + I_{t-1} \tag{2}$$

$$I_{t-1} = \alpha B_{t-1}(Y_{t-1}, i_{t-1}, P_{t-1}, \omega_{t-1}), where B_y > 0, B_i < 0, B_p > 0 \tag{3}$$

$$D_t = K_t \tag{4}$$

Equation (1) describes the market demand D_t for commercial property at current prices P_t which is a function of the number of potential investors N and their access to bank credit for commercial property L. It is assumed that these investors differ only in terms of their reservation price due to either private information or different valuation approaches. The sum of these reservation prices follow a cumulative distribution function, $F(P_t)$. If an investors reservation price exceeds the current market value, they will pursue the property and seek external funding. Investment in commercial property is usually highly leveraged and bank credit is a key source of funding. To overcome asymmetric information on the degree of counterparty credit risk on the loan contract, banks demand collateral so its price is closely linked to credit growth (Kiyotaki and Moore, (1997) and Bernanke *et al.*, (1994)). A positive relationship is assumed between credit and current prices. Credit market imperfections and possible departures from rational expectations are cited as reasons for the assumed reliance on current prices by banks. DZ also assume that credit availability is positively related to the investors

[8]The lack of published academic research on modelling Irish capital values may reflect the fact that Irish commercial property data are not publicly available.

[9]In using this approach the paper builds on previous work undertaken in the Central Bank of Ireland in Bermingham, C., Doyle, N., and Woods, M. (2009), "Irish Commercial Property Prices", mimeo.

endowment which can be proxied by personal disposable income or real Gross Domestic Product (GDP). Investors can borrow more if interest rates,i_t are low and banks lending standards, ω_t. are accommodative.

Equations (2) and (3) focus on construction and supply side dynamics. If construction costs exceed replacement cost, developers will initiate new projects (using bank financing). Construction supply is assumed fixed in the short run (one period) due to development lags. Therefore the stock of new supply K_t will evolve according to (2) where δ is the depreciation rate and I_{t-1} is the stock of completed development projects last period, which like investment also depends upon bank credit for financing B_{t-1}. The same factors which determine credit supply to investors are also assumed to apply to construction financing. The market clears when demand equals supply (4) so market prices P and level of commercial property K are assumed to be constant over time in equilibrium.

The model predicts that prices and bank credit are positively related but bank credit may have negative impact on prices in the long run if there is oversupply. While it is assumed that income and interest rates impact commercial property prices, the macro effects may vary across markets depending on the relative elasticity of supply and demand. DZ contend that if the supply response is relatively elastic, overbuilding in response to a positive income shock will dampen price growth leading to a price cycle. Conversely if the supply response is quite slow, market prices may increase even faster than fundamental prices resulting in misalignment.

DZ use this framework to examine the macro-economic determinants of commercial property prices using an unbalanced panel of 17 countries, including Ireland, generally over the period 1973 to 2003.[10] The paper uses both panel and vector error correction models for individual countries. The empirical work relies on the following five variables; real commercial property prices, real GDP, real interest rates, and real private investment. In general, the results accord with the model in that a positive relationship is found between GDP and prices in both the short and long run while credit is found to positively related to prices in the short run but negatively related in the long run.

2.2 Model of Irish commercial property prices

Following DZ we hypothesise that current Irish commercial property prices (C_t) are determined by macro-economic determinants (X_t) such as real GDP, long-term interest rates and credit, among other factors.

$$C_t = \beta_t X_t + u_t \tag{5}$$

The Irish commercial property market has experienced significant swings over the last 30 years (Figure 2). Commercial property capital values (for simplicity referred to as prices throughout this paper) experienced an initial cycle in the period around 1990, although this was dwarfed by subsequent developments. Between 1995 and 2007 real prices increased over 200 per cent, with only a short-term adjustment around 2001/02

[10]The Irish data are annual and cover the period 1982 to 2003.

interrupting the constant upward trajectory. This was followed by a collapse which saw prices decline by almost 70 per cent and it has only been in recent quarters where price growth has re-emerged. The cycle in real rents in comparison was somewhat more modest although still significant. Commercial property rents increased by about 70 per cent between the mid-1990s and 2001 before it plateaued at this level for much of the 2000s. During the subsequent collapse real rents fell by about 50 per cent. Similar to prices, recent quarters have seen a return of rental growth. The gap between rental growth and price appreciation pre-crisis raised concerns about potential misalignment in the market. Simple indicators of misalignment such as the price-to-rent ratio (Figure 1)or its inverse, the property yield were above historical averages.

Ireland experienced rapid economic expansion from the late-1990s with a marginal slowdown in 2000/01. The *Celtic Tiger* years was a time of economic convergence on our European counterparts. Unsustainable economic imbalances, however, arose towards the end of this time with domestic demand heavily reliant on property. Even in the absence of a credit channel, an increase in economic growth should lead to an increase in investor demand for commercial property, all other things being equal. This is a derived demand equation as investors anticipate an increase in demand for rental space for offices, retail and industrial units. This in turn, leads to an increase in expected income/rental return on commercial property, which may increase investors reservation price. Figure 3 shows that the annual change in real commercial price and in real GDP in Ireland appear to move broadly in tandem between 1985 and 2012. Property prices appear to have relatively greater amplitude.

According to Woods (2007), commercial property-related credit increased significantly up to 2007, accounting for a quarter of total private sector credit to Irish residents. Financial liberalisation and deregulation during the 1980s and 1990s followed by closer integration of European capital markets in 2000s allowed banks to increase their credit supply to meet rising demand. The close links between corporate credit and commercial property prices are shown in second panel of figure 3.

In line with theory we expect a negative relationship between long-term real interest rates and commercial property prices. An increase in funding costs faced by investors can lead to a decline in demand for commercial property. Also long-term real interest rates may proxy the discount factor or required rate of return. Interest rates and prices are compared in figure 3. The period between the advent of European monetary union (1999) and the beginning of the global crisis (2007) saw historically lower interest rates and this coincided with high commercial property prices in Ireland.

Table (1) displays some descriptive statistics for real prices, income, credit and interest rates over the period 1985 to 2012. Although prices, credit and GDP did record similar levels of maximum quarterly growth (circa 9 per cent) over the period, the first two series recorded relatively higher maximum quarterly declines. Prices fell by almost 19 per cent, credit by 16 per cent while GDP declined by 6.3 per cent in one quarter. The rental series did not increase to the same extent as prices, credit or GDP with a maximum growth rate of 6.3 per cent over the sample.

All of the aforementioned factors focus on demand-side influences. Unfortunately a long-run consistent series on commercial property supply in the Irish market is not

available. There have been some papers on supply-side dynamics but these are based on low frequency data. Some examples are McCartney (2008, 2011) which refers to the Dublin office market. DZ use private investment as a proxy but in the Irish case, this variable would be highly correlated with GDP, given the role of domestic demand in driving economic activity prior to the crisis.

Lagged commercial property prices are considered as a possible explanatory variable in one of the specifications in line with DZ. There is a high degree of persistence in the Irish commercial property price data, which is common in valuation-based indices (See section 3.1). In addition to valuation practices, low levels of liquidity/market transactions and the general heterogeneity of assets in this market complicate the price discovery process. Other issues potentially leading to price errors by investors or valuers are the dependence on local knowledge (Zhu, 2003), high transaction costs, lack of a common market place and the inability to engage in short-selling practices (Hendershott *et al*., 2005). Therefore, as noted by DZ, prices may deviate from fundamental values because of market-specific characteristics creating endogenous cycles which amplify the effects of economic factors. Although we cannot fully control for these idiosyncratic market features, the inclusion of a lagged dependent variable in our specification may go some way in capturing institutional features that can cause persistence in the data.

Given the range of possible estimates of a fundamental commercial property prices and the data issues on the supply side we also use a number of simple statistical indicators to approximate potential misalignment as a complement to the regression-based approachs.

2.3 Nature of misalignment - fads versus bubbles

The second element of the analysis examines the nature of the periods of misalignment in Irish real commercial property prices using the analytical framework of Schaller and Van Norden, (1996, 2002, hereafter SVN). The SVN approach is based on two particular strands of the equity price literature that seek to explain why prices vary so much relative to the intrinsic value of the asset. The two strands are fads and rational bubbles. Although potentially similar in general terms, the explanation for fads and rational collapsing bubbles differ in the dynamic description of price behaviour and in their assumptions regarding the rationality of market participants.

Fads are associated with some form of irrationality among investors that cause prices to temporarily deviate away from equilibrium values (Schiller, 1984). As prices are assumed to eventually return to an equilibrium value, proponents of the fad theory believe that price changes may, therefore, be predictable at certain horizons, which conflicts with the efficient market hypothesis (EMH). The fads model of Cutler, Poterba and Summers, (1991) is used in the SVN framework.

It is assumed that asset prices have both a fundamental (p_t^f) and non-fundamental (p_t^{nf}) component with lower case denoting logs in all equations.

$$p_t = p_t^f + p_t^{nf} \tag{6}$$

The fundamental price is assumed to be non-stationary and v_t is a white noise error term.

$$p_t^f = p_{(t-1)}^f + v_t \tag{7}$$

$$v_t \sim iid(0, \sigma_v^2)$$

The non-fundamental price is assumed to follow a stationary autoregressive process of order (1) with the coefficient ρ bounded between zero and one. The assumption of this stationary component implies that returns are predictable.

$$p_t^{nf} = \rho p_{t-1}^{nf} + e_t, \tag{8}$$

$$1 > \rho > 0, e_t \sim iid(0, \sigma_e^2)$$

Fundamental prices are difficult to observe in practice so p_t^f must be estimated using a proxy p_t^p which introduces some measurement error, w_t.

$$p_t^p = p_t^f + \omega_t, \tag{9}$$

$$w_t \sim iid(0, \sigma_\omega^2)$$

By re-arranging (6) to (8), we can express log price changes between period *t* and *t+1* relative to deviations between actual prices and the proxy for fundamental prices.

$$p_{t+1} - p_t = \beta_0 + \beta_b(p_t - p_t^f) + e_{t+1} \tag{10}$$

Then assuming $\omega_t \approx 0$ in (4), we can replace p_t^f with p_t^p to yield (6)

$$p_{t+1} - p_t = \beta_0 + \beta_b(p_t - p_t^p) + e_{t+1} \tag{11}$$

The difference between the actual price and the fundamental price at time t is assumed to have explanatory power for price changes at time $t + 1$ if the market is subject to a "fad ". If the asset price series follows a fad, the coefficient β_b should be negative so that any misalignment or gap will fall over time. An increase in the gap today leads to a decrease in rate of price growth tomorrow. As these misalignments are not sustainable, prices do not exhibit explosive behaviour.

The term "bubble" is often more popular than "fads" to discuss periods of boom and bust in asset prices among the general public. The SVN framework focuses on stochastic bubbles as defined by Blanchard and Watson, (1982, hereafter BW) where collapsing bubbles are assumed to be jointly consistent with the *no arbitrage* assumption of the EMH in the presence of rational expectations. In equilibrium, an asset price P_t is assumed to equal the discounted present value of future income or dividends D_t, with the latter assumed to represent the fundamental price. The discount rate r is assumed constant.

$$P_t = \frac{E_t(P_{t+1} + D_t)}{1 + r} \tag{12}$$

According to BW, there are other price solutions, which satisfy the equilibrium condition. The market price can, therefore, deviate from fundamental values without violating the no arbitrage condition. Prices are assumed to contain both a fundamental and

bubble component, with the size of the bubble B_t given by the following equation,

$$B_t \equiv P_t - P_t^f \tag{13}$$

The bubble must grow each period at a rate r to entice investors to participate in the market.

$$E_t(B_{t+1}) = (1+r).B_t \tag{14}$$

BW consider one possible example of a rational bubble where the bubble will survive in state S or burst in state C with probability, q and $1-q$ respectively. If the bubble lasts, the actual return must be higher than r so as to compensate for the probability of a crash.

$$E_t(B_{t+1}|S) = (\frac{1+r}{q}).B_t \tag{15}$$

The expected value of the bubble in a collapse is zero. In other words if the bubble is positive and it collapses the actual price falls by the value of the bubble.

$$E_t(B_{t+1}|C) = 0 \tag{16}$$

In summary, stochastic bubbles are assumed to be consistent with rational expectations, even though prices can move out-of-line with fundamentals, as the expected discounted value of future bubbles is reflected in current prices. Although these bubbles are assumed to grow over time, they will eventually burst with some probability. As actual prices increase above the fundamental prices, the probability of crash increases, justifying further increases in price or higher returns to compensate investors for the corresponding increase in risk (Evans, 2003). Investors know that there may be a bubble and that prices will eventually decline. They will participate in the market as they believe they can exit before the price collapses (Taipalus, 2013). Stochastic collapsing bubbles can occur in certain markets where fundamentals are difficult to assess; there are no constraints on short-selling and there are new market participants over time (Blanchard and Watson, 1982).

SVN extend the BW model in two ways. First it assumed that the probability of the bubble surviving, q is negatively related to the proportional size of the bubble b_t.

$$b_t \equiv \frac{B_t}{P_t} \tag{17}$$

Second, SVN allow for the possibility that bubbles may partially collapse in a particular period as they contend some market crashes may be gradual rather than instantaneous. They relate the expected size of the bubble in state C to the size of the bubble in the previous period. Applying a first-order Taylor expansion to the conditional expected returns in each state, SVN derive the following linear expressions for the expected returns (omitting the expectations operator).

$$R_{i,t+1} = \beta_{i0} + \beta_{ib}.b_t + e_{i,t+}, \tag{18}$$

$$e_{i,t+1} \sim N(0, \sigma_i^2), i = S, C$$

Equation 18 is the general regime switching model of SVN. The bubbles model implies that expected returns vary depending on the prevailing regime. Expected returns

should be higher in the survival state relative to collapse state. Consequently, $\beta_{s,0}$ need not equal $\beta_{c,0}$ and $\beta_{b,s}$ must be greater than $\beta_{b,c}$.

Many empirical papers test for the presence of fads and collapsing bubbles separately but the approach of SNV facilitate the joint testing of both. The novel feature of SVN is the assumption that the error term in (11) is heteroscedastic due to presence of two states [11]. It is assumed that the variance of σ_e^2 in the survival period is less than the variance in the crash period. Many of the empirical tests for the presence of fads find that the residuals are heteroscedsatic .With this innovation, the fads model is nested within the general regime switching specification for a rational bubble.

The fads model implies that expected returns (conditioned on B_t) will be the same over the sample. The equality of the point estimates for the intercept and slope coefficients can be tested using Wald Tests. Both restrictions can be jointly tested using Likelihood Ratio tests. If $\beta_{s,0} \neq \beta_{c,0}$ and $\beta_{b,s} \neq \beta_{b,c}$ we cannot accept the series under study conforms to the fads model and must consider the alternative hypothesis of a rational bubble. Conversely, if the restrictions are found to be valid, we must reject the hypothesis of a bubble in favour of the fads model.

SVN applies this approach in a number of papers covering exchange rates and equity prices. One such example is Schaller and Van Nordon, (2002). The authors examine monthly US stock price data over the period 1926 to 1989 for evidence of fads or rational bubbles using regime switching techniques. In summary, the paper finds that the data do not fully conform to the fads hypothesis but there is not overwhelmingly consistent evidence in favour of rational bubbles.

In an Irish context, Roche, (1999) looks at Dublin and UK house prices from late-1970s up 1999 and applies the SNV regime switching framework. The paper tests between three hypotheses, namely prices can be explained by fundamentals, fads or stochastic bubbles. Both endogenous and exogenous switches are assumed. Roche, (1999) finds evidence of a stochastic bubble but estimates that the probability of a crash in Dublin house prices in 1999 was less than the probability estimated for Britain in late-1980s. The UK housing market suffered a significant adjustment in late-1980s/early-1990s.

To apply this approach to the Irish market, we use our estimate of fundamental commercial property prices or its deviation from actual prices (i.e., non-fundamental component) to obtain our explanatory variable. The need to proxy this component introduces measurement error. Therefore, any estimate of a non-fundamental price may be biased. However according to Roche (1999, 2000), even if we miss-specify the magnitude or the relative size of the bubble term, it should not affect our tests for regime-switching models. Wald tests for coefficient restrictions and the Likelihood-Ratio (LR) tests are not sensitive to linear transformations of non-fundamental prices/bubble component. Therefore, while noting its existence we assume that the measurement error is negligible. Simple switching methods based on Quandt, (1958) are used by SVN to estimate (18). This approach assumes a particular stochastic process for the

[11] SNV assume heteroscedastic returns for two further reasons. First, to ensure that when testing for fads, the presence of heteroscedastic residuals do not affect the results. Second, this assumption is invoked to ensure possible identification of the fads model with hypothesis testing.

transition probabilities which is based on mixture normal distributions. The probability of the occurrence of a particular state in period t is independent of the prevailing state in period $t-1$. In the case of fads model (11), SVN assume that the volatility of the residuals moves randomly with the state and do not allow for any persistence in stock market volatility. With regard to the bubble model (18), it is assumed that the probability of the bubble regime surviving, (q) is a function of the relative size of the bubble (b_t).The institutional features of commercial property markets and preliminary examination of the Irish price data in section 3 suggest that an assumption of some persistence may be important. Although the random variable governing the switch between regimes is often unobserved, the use of a probabilistic model based on a Markov chain imposes some structure on the data generating process for this random variable (Hamilton, 2005). A first order Markov chain implies that the probability that the data process is in a particular regime or state S at time t is dependent on the regime in the previous period.

$$Prob[S_t = i|\Omega_{t-1}] = Prob[S_t = i|S_{t-1} = j] = p_{ij}] \tag{19}$$

where p_{ij} is the probability of moving from regime j to regime i and is subject to $0 \leq p_{ij} \leq 1$ and $\sum_{j,i=1}^{2} p_{ij}$. We assume constant rather than time-varying transition probabilities (TVTP) for a number of reasons. First, it can be challenging to estimate the parameters of the transition probability matrix accurately using TVTP, especially if there are only a small number of switches between regimes (Hamilton, 2005). Second, the choice of indicator series may be difficult. It is not clear if the proportionate size of the bubble or misalignment, although plausible, would be the main factor determining regime shifts in the commercial property market over the full sample. We therefore have the same levels equation as SVN (18) but the transition probabilities differ. [12]

3 Data

3.1 Commercial property market data

Both the price and rent series used in this paper are the "all property" series from the Society of Chartered Surveyors & Investment Property Databank (SCS/IPD) Ireland index.[13] We use data covering the period 1984 through 2014. While the index is available for the entire period, prior to 1995 the index is at an annual frequency. Quarterly data is available from the 1995 onwards. Therefore the annual series from 1984-1994 is interpolated to form a quarterly series for this time period.

In common with most other international commercial property data, the SCS/IPD Irish Index is based on valuations of standing investments by participating investors

[12] According to Schaller (1996), if their model is estimated using Markov rather than simple switching, similar dynamics may be captured, if there is a bubble. The transitional probabilities in SVN are driven by proportionate size of the bubble which can be serially correlated.

[13] Based on the IPD Index Guide, Edition Eight, 2012 the index covers in the region of 80 per cent of the commercial property market in Ireland as at December 2011. In terms of portfolio composition properties included the index are mainly in the Dublin area.

rather than actual transactions in the market.[14] A number of papers have looked at the implications of using a valuations approach to index compilation rather than a transactions approach. Ball, Lizieri and MacGregor (2006) highlight that these valuation indices suffer from smoothing which can lead to low volatility and complicate comparisons with other asset classes where price data are freely available. Additionally, Whitley and Windram (2003) highlight that low market liquidity makes it difficult to assess if these valuation-based indices are representative of movements in actual market capital values.

The SCS/IPD index is calculated at the property level and designed to measure the return to be expected from held investments without active management. Index calculations exclude the impact of debt, fund management fees, taxation and cash. Similarly, properties are excluded where the change in value is due to non-market factors (e.g. major capital expenditure, unique event such as damage from fire or flooding). In order to convert the SCS/IPD index to a price series in levels, an average commercial property price per square metre is estimated from sectoral (i.e., office, retail and industrial) rent and yield data from CBRE[15]. These data are aggregated using a weighted-average based on each sector's share of the IPD portfolio in Q1 2013. Data are in euro per square meter.

3.2 Macroeconomic data

Long-run quarterly macroeconomic series for Ireland are in short-supply. As a result, in some cases, official data from the Central Statistics Office (CSO) Quarterly National Accounts have been supplemented in order to create a quarterly series back to 1984. Internal Central Bank of Ireland (CBI) data for the period 1984-1997 was combined with CSO data for the later period to create a quarterly time-series for GDP, consumption and employment. The credit series used in the paper, which relates to credit issued to non-financial corporates, comes from CBI Credit, Money and Banking Statistics. The series is publicly available from 2003 and is internal CBI data for the period prior to this.

Inflation, measured by consumer price index (CPI), and the seasonally adjusted standardised unemployment rate are available for the entire period, from the CSO and Datastream respectively. Financial data used, also sourced from Datastream, are Irish government bond yields (redemption yield on benchmark 10 year bond).

3.3 Preliminary statistical tests

Prior to estimation, real GDP, real corporate credit and real commercial property prices[16] are transformed into logs. First differences are taken to remove the unit root identified using Augmented Dickey-Fuller (ADF) test. Table 2 presents the results of the unit root testing for the transformed variables. For robustness, as unit root tests are considered to have low power, two formal tests are used, namely Phillips-Perron (PP) and ADF.

[14] Efforts have been made in recent recents to develop transaction based indices, however at present these remain work in progress.

[15] CBRE EMEA Rents and Yields Market View Q1 2013.

[16] Nominal series are deflated using the CPI in order to create necessary real variables.

For the PP and ADF tests, four lags and a constant are chosen.[17] No trend is included as the data are in first differences. Both of these tests incorporate a null hypothesis of a unit root. The PP test indicates that all four differenced variables are integrated of order (0). This result is confirmed for interest rates and prices but not for credit or GDP using the ADF test with four lags. However, using two lags, the ADF test confirms that a unit root is not present in both variables, albeit at 10 per cent significance for credit.

The preceding paragraph shows that our variables of interest are integrated of order(1). We now turn to testing for possible cointegrating relationship given the theoretical justification for long-run relationship between the variables. Given that we could have potentially more than one cointegrating vector, we rely on the Johanson (1988) methodology to test for the number of cointegrating equations. We find no evidence of cointegration using all four variables over our full sample period. However, omitting credit, we find some evidence of one cointegrating vector between prices, GDP and interest rates using both the trace and maximum eigenvalue statistic. It is this result that is used in the next section to approximate a fundamental commercial property price. However, we believe that credit was an important part of the Irish commercial property story and given the literature linking property and credit cycles we also specify a simple time-series model to estimate the relationship between prices and credit, while also controlling for GDP and interest rates.

4 Estimation

4.1 Cointegration - income and interest rates

A long-run relationship is assumed to exist between commercial property prices, GDP and interest rates, all in real terms, given the results of the cointegration testing and based on theory. We use the Engle-Granger (1987) two-step approach as we are interested in recovering the long-run relationship to approximate our fundamental price. We run our initial estimation on the period 1985Q1 to 2012Q4 using the data up to 2013Q4 to check for model adequacy. The following log-linear specification is used,

$$c_t = \alpha_t + \beta_t gdp_t + \gamma_t i_t + \mu_t \tag{20}$$

where c_t is the log of real commercial property prices, gdp_t is the log of real gross domestic product and i_t is real long-term interest rates. In addition to simple Ordinary Least Squares (OLS), Fully Modified OLS (FM-OLS)[18] is used to estimate the regressions as the latter controls for potential endogeneity and serial correlation [19].

[17] The critical values for the ADF test are those that are linearly interpolated from the Fuller (1976) results, while the MacKinnon approximate p values in the PP tests are based on MacKinnon (1994).

[18] According to Enders (2004, pg339), inference may be inappropriate if there is evidence of serial correlation in the errors of the cointegrating vector. Endogeneity may also be an issue. In this instance, the procedure of Phillips and Hansen (1990) may be used instead. This procedure adds leads and lags of changes in the explanatory variables to the regression and adjusts the t statistics from the original equation using a modified version of the variance of the error term from the expanded equation.

[19] Tests for higher-order serial correlation using Ljung-Box test on the OLS residuals suggest the presence of autocorrelation

Table 3 shows the results, which are quite similar across both methods. The explanatory variables have the expected sign and are statistically significant. A one per cent increase in real GDP will lead to a 0.3 per cent increase in real capital values, all other things being equal. As interest rates are not in logs, γ_t shows the semi-elasticity of prices with respect to rates.

Figure 4 plots the actual prices against the fitted values from the OLS regression and also displays the residuals over the sample period. Although the fitted values track the actual values, there are periods of deviation between the two series. Actual prices are above the fitted value (i.e. approximation of fundamentally justified price) in the late-1980s/early-1990s, briefly in the late-1990s and from 2004 to late-2007. There is a spike in the residuals in 2009/2010 suggesting overvaluation which would be contrary to intuition given that this was a period of falling prices and financial stress. This misalignment seems to be driven by the relatively higher fall in the fundamental price or fitted values.

We formally test stability of the estimated parameters using Bai-Perron tests and recursive least squares (RLS) on the long-run equation (20). The RLS results indicate that although the coefficient on real GDP is broadly stable, the coefficient on the interest rate variable appears to trend downwards slightly from 2009/2010 (Figure 5). The Bai-Perron Break Point test indicates that there may have been a slight shift in the estimated relationship between the explanatory variables and prices in 2009.

The residual from (20) is used as the non-fundamental prices although we note the concerns regarding the stability of the relationship towards the end of the sample. The second stage of the Engle-Granger approach incorporates the residuals of the long-run cointegrating relationship into a short-run dynamic model of price changes. Table 3 shows the results of the error correction model. The Error Correction Term, ecm_{t-1} is found to be significant and negative. If there is a deviation between actual and fitted values last period, this deviation will be reduced at a rate of 4 per cent per quarter. Misspecification testing on the residuals reveal no evidence of autocorrelation [20]. Some evidence of autoregressive conditional heteroscedasticity (ARCH) effects at lags 2 and 4 lead us to use heterscedasticity consistent robust standard errors. In terms of further assessing the adequacy of the model, we conduct a pseudo out-of-sample estimation using actual data up to 2013Q4. Figure 6 compares the forecasts of our ECM model for quarterly differences in log commercial property prices and the actual outturn. The model seems satisfactory.

4.2 ARDL model with credit

The cointegration approach showed periods of misalignment between actual and fundamental prices, indicating a possible role of non-fundamental influences. However it may be that some of the misalignment may be due to the omission of credit. This section attempts to address this issue. Our second approach uses an Autoregressive Distributed Lag (ARDL) specification. This model incorporates short-run influences

[20]The Breusch-Godfrey LM test for Serial correlation is 1.65 with a significance level of 0.19 for first order serial correlation and 4.9 with a corresponding significance level of 0.29 for fourth order serial correlation.

from changes in real GDP, real long-run interest rates and real corporate credit in addition to controlling for lagged commercial property prices. The following specification is used to estimate an $ARDL(p,q)$ model in first differences:

$$\triangle cp_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \triangle cp_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle gdp_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle i_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle cred_{t-i} + \mu_t \quad (21)$$

where $\triangle cp_t$ is differenced log real commercial property prices, $\triangle gdp_t$ is differenced log real gross domestic product and $\triangle i_t$ is differenced long-term real interest rates and $\triangle cred_t$ is differenced log corporate credit. The initial lag length for the explanatory variables q and for the lagged dependent variable p was chosen by the Akaike information criterion (AIC). Contemporaneous GDP, interest rates and corporate credit are also included in the specification. The AIC was lowest at lag two for all variables. We then employed a general-to-specific approach to obtain a parsimonious specification.

The overall fit of the model as estimated by the adjusted $\overline{R^2}$ is relatively high at 80 per cent (Table 4). Lagged long-run interest-rates are found to be significant with a negative sign. As suspected, lagged values of the dependent variable exert a significant influence of up two quarters on commercial property prices showing that Irish commercial property prices are quite persistent. Real GDP is found to be significant and positively related to prices. Credit has a contemporaneous effect on capital values [21]. Misspecification testing on the residuals from the $ARDL$ model indicates some evidence of ARCH effects.So we use heterscedasticity consistent standard errors. Our first lag of real GDP now becomes insignificant so we omit it from the model. Table 4 shows our final specification with figure 7 showing the actual and fitted values of the regression along with the residuals.

The fitted values from the ARDL regression yield estimates of quarterly changes in fundamental capital values. We convert these quarterly changes into a price index with the third quarter of 1995 set equal to 100. The percentage deviation between the actual price index and fundamental index is calculated and from this an index measuring deviations between actual and fundamental capital values is constructed. It is assumed that the non-fundamental value is correlated with this index. In general results are in line with the long-run model.

5 Statistical indicators

As a complement to the econometric estimates above we also estimate misalignment in commercial property prices using a simpler statistical approach.

[21] Investigating the direction of the relationship between credit and commercial property prices could be an area of further work as has been done for house prices in Gerlach and Peng (2005) and Fitzpatrick and McQuinn(2004). Granger causality tests are not useful here as we are concerned with the contemporaneaus relationship and possible simultaneity bias.

5.1 Commercial property price gap

The first estimate is based on the commercial property gap. The gap at any point in time is calculated as the difference between the actual level of the price index and its long-term trend and expressed in units of the underlying variable, in this case index points. It is based on the concept that the price index can be decomposed into a trend component (tau) and a cyclical component (c).

$$cp_t = \tau_t + c_t + \epsilon_t \tag{22}$$

As is becoming common practice in this area, we apply a one-sided Hodrick-Prescott filter with a smoothing parameter (lambda) of 400,000 to calculate the trend.[22] As discussed in Drehmann *et al.*, (2011) a one-sided, or recursive, approach is taken as it only utilises information available at each point in time in the calculation of the trend component replicating the information that would be available to a policy maker at a particular point in time. The Basel Committee on Banking Supervision (BCBS) recommend the use of a lambda of 400,000 in relation to the credit-to-GDP gap based on the observation (see Drehmann *et al.*, 2012) that the credit cycle can be substantially longer than the traditional business cycle[23]. Aikmen *et al.*, (2011) note also that property cycles tend to be longer than the business cycle and more in line with credit cycles. Giese *et al.*, (2012) and ESRB, (2014) both utilise a lambda of 400,000 in the estimation of commercial property gaps.

Applying this methodology to Irish commercial property prices suggests a real commercial property gap as shown in Figure 8. The first panel shows the real capital value index and the underlying trend with the second and third panels showing the associated gap in absolute and relative terms respectively. The shaded area indicates the recent financial crisis.[24] As has been found in other papers a positive gap was evident in advance of the onset of the crisis. The gap was positive from the late-1990s building up to a peak in the early 2000s before declining but remaining slightly above zero. A second build-up of the gap is evident in 2005/06. It is noticeable that this second peak in the gap in commercial property prices occurred in advance of the beginning of the crisis. This is consistent with the findings of others including Drehmann *et al.*, 2010 where deviations from trend were deemed useful in identifying the build-up phase but narrowed before financial strains began to emerge. The gap has been consistently negative since mid-2008 and although the extent of the gap has been reducing in recent quarters it remains significantly negative. The final panel shows how using alternative lambda values impacts on the estimate of the gap.

[22] The Hodrick-Prescott filter is the solution for which the trend component optimises the equation

$$MIN_{\tau}(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2)$$

where is a fixed value.

[23] Where typically a lambda of 1,600 tends to be applied to quarterly data.

[24] 2008Q3 is used as the starting point of the crisis as it coincides with significant intervention in the banking system, including the State Guarantee of September 2008.

5.2 Commercial property prices and the economic cycle

A second statistical approach to estimating misalignment in commercial property prices is based on the observation that commercial property price movements tend to follow economic developments. This kind of approach has been used by the European Central Bank (ECB) to look at misalignment in commercial property prices in their Financial Stability Review[25]. A number of indicators are constructed based on variables that are expected to have an influence on the demand for commercial property such as nominal GDP, employment and consumption. Rents are also included as a proxy for the future income stream received by investors in this asset class. The ratio of the price to each of these variables is constructed over our sample period with misalignment measured as the deviation in the point-in-time level of each indicator from the average level for that indicator over the sample period.

The indicators should not be read as a precise estimate of over- or under-valuation in commercial property prices. Indeed, the level of misalignment at any point in time can vary substantially across individual indicators. Additionally, there is no reduced form or structural econometric model behind the relationships and the level of misalignment can be sensitive to the sample time period - although this is mitigated in the analysis here due to the long sample used. Finally, capital values may adjust more rapidly than other variables (changes in rents for instance could be slower to take effect as contracts may be fixed). In this case indicators may potentially overstate (negative) misalignment at a particular point in time.

Notwithstanding the above, the combination of indicators may provide an insight into general trends in developments in commercial property market. Figure 9 shows the average level of misalignment across the four indicators and the range around it. While noting the large variation across indicators it does seem to suggest that positive misalignment was a feature of the market throughout the 2000s, increasing towards the mid-to-late 2000s before a rapid reversal in 2008 since when values have been below average levels. The most recent quarters are showing signs that the level of negative misalignment may be beginning to reduce.

6 Testing for a fad or bubble

In previous sections, we showed that there were a number of periods where actual real Irish commercial property prices deviated from our estimates of a fundamental price or from its long-run trend. In this section we investigate the nature of the estimated misalignment and test whether Irish real commercial property prices conform to the irrational fads hypothesis or the rational collapsing bubble theory using a slightly modified SVN approach as discussed in section 2.

In table 5 we show the results of the estimation of the general regime switching (bubble) specification (18) of quarterly log commercial property growth. The various measures of non-fundamental price or deviation between actual and fundamental prices are included as the explanatory variable along with a constant. The label *ECM*

[25] See ECB Financial Stability Review December 2011 Box 6 for details.

refers to the non-fundamental price recovered from the long-run cointegrating relationship in the error correction model using GDP and interest rates. The label *ARDL* is for the autoregressive distributed lag model using GDP, interest rates, credit and lagged commercial property prices, and finally, the *statistical* term represents the statistical measure of average misalignment from section 4.2.

The results of the switching regressions are not conclusive across all three models. Only the ARDL has statistically significant point estimates for both the slope and intercept coefficients across both regimes. It is also the only model that rejects that validity of the Fads model using both the Wald and Likelihood ratio tests[26] in Table 6. The ECM cannot reject the hypothesis that the slope and intercepts are different at the 5 per cent significant level using both tests. For the statistical approach, the LR test suggests that we cannot accept the joint validity of the Fads restrictions although the Wald test does not suggest that the point estimates for intercepts are statistically different across the regimes.

There seems to be some evidence that there is more than Fads in Irish commercial property prices. The results suggest that a rational bubbles hypothesis might explain real commercial property prices over the sample period. However we cannot make a definitive conclusion as the results do not support all of the implications of the bubble model. Our bubbles model says that the coefficients on the bubble term, or non-fundamental price,β_b in the survival period should be greater than the corresponding coefficient in the crash regime. This only holds in our final column using the statistical methodology. In terms of interpretation, if we take one of the larger values of b_t which is 29 per cent in 2006 Q1, our point estimate of 0.06 implies a change in expected real commercial property price returns, of 1.74 per cent per quarter or just under 7 per cent annualised, all other things being equal.

The last two rows in table 5 show estimates for the transition probabilities. In all three cases, it appears that both regimes are persistent, although the probability of staying in the survival regime is marginally higher (i.e., 0.94 to 0.98) than the probability of staying the crash regime (i.e., 0.85 to 0.92). The expected duration of the survival period is between 4 and 12 years while the duration of the crash period is 1.7 to 3 years. The probability of moving to a crash regime from a survival period is between 2 and 6 per cent based on the sample data.

Figure 10 compares the smoothed probabilities of the survival state using both approaches. Smoothed probabilities allow us to infer the state or regime that Irish real commercial property prices were in on a given date using the information over the full sample. [27] The timing of these regime switches seem to generally coincide with our estimated periods of misalignment.

7 Summary and conclusion

This paper aims to further the macro-prudential risk assessment of commercial property markets, given its key role in a number of systemic crises in advanced economies.

[26]The Wald test is asymptotically distributed with one degree of freedom, when the null is correct, while the LR test is asymptotically chi squared distributed with two degrees of freedom.

[27]Smoothed probabilities are based on an algorithm by Kim, (1994). See Hamiliton, (2008).

The research focuses on the Irish market and examines real price movements in the Irish commercial property market over the period 1985 to 2012. Two reduced form models are specified and estimated which incorporate theoretically motivated explanatory variables for commercial property prices such as income, interest rates and credit. Our models do not have supply side indicators given the lack of long-run Irish data on this side of the market. Commercial property prices are found to exhibit significant persistence which may be due in part, to mypoia on the part of investors, institutional features of the market such as supply lags or the fact the data are from a valuations-based index. Such features may also create price cycles in addition to macro or credit variables. We try to capture this feature with a lagged dependent variable.

Although these models are found to provide a good description of prices, there are a number of periods where actual prices are found to persistently deviate from the estimated fundamental prices. As a fundamental commercial property price is unobservable and what constitutes a fundamental determinant remains subject to debate, a suite of indicators is preferable for robustness. The paper approximates a simple estimate of misalignment between actual and fundamental prices using a number of statistical indicators. The periods of estimated misalignment are found to be broadly consistent across the approaches. We find that Irish commercial property prices appear to be overvalued relative to fundamentally justified values in the early 1990s and between 2000 and 2008. The results suggest undervaluation in the mid-1990s and from 2009/10 to the end of our sample.

To further our understanding of commercial property price dynamics, we draw on two popular models of price misalignment from the stock price literature. Specifically, we test whether these estimated misalignments between actual prices and fundamentals (i.e., non-fundamental prices) suggest that there is an irrational fad or a rational bubble in Irish commercial property prices. These models attempt to explain the non-fundamental component of prices that can be attributed to investor behaviour over the property cycle. A better understanding of the dynamics of commercial property prices will help the modelling and forecasting of prices. To distinguish between these two models, regime switching methodology is used. We fail to accept the fads hypothesis. Therefore, the alternative hypothesis of a rational bubble must be considered. Although there is some evidence of non-linearity and the timing of the regime switches mirrors our estimated periods of misalignment, the empirical results, however, do not fully conform to the stochastic bubble theory.

Indicators of misalignment in commercial property prices have been identified as potentially useful in the identification of financial crisis and are being looked at in terms of practical implementation of macro-prudential policy. As such, the measures outlined in this paper should add to the financial stability analysis of Ireland and may potentially be useful in the implementation of macro-prudential policy. One of our indicators attempts to cature real time behaviour of indicators by recursively estimating misalignment. Lags associated with certain macro-economic data releases and the low frequency nature of the data (i.e., quarterly), however, imply that such indicators may lag market events. Therefore, policy-makers should complement these indicators with market intelligence.

Further research could address a number of different avenues. There are a number of other possible tests for bubbles that rely on unit root tests (e.g.,Hall and Sola, 1993)

which could be applied to the Irish market . The literature also highlights that a bubble may be observationally similar to a structural break in fundamental prices. There are some concerns that credit in Ireland exhibited bubble-like behaviour over the sample period, especially in the years leading up to the Irish crisis. Also real interest rates may not have been in equilibrium over the sample. Therefore further study of these determinants would be useful.

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Figures & Tables

Figure 1: Commercial property price-to-rent ratio

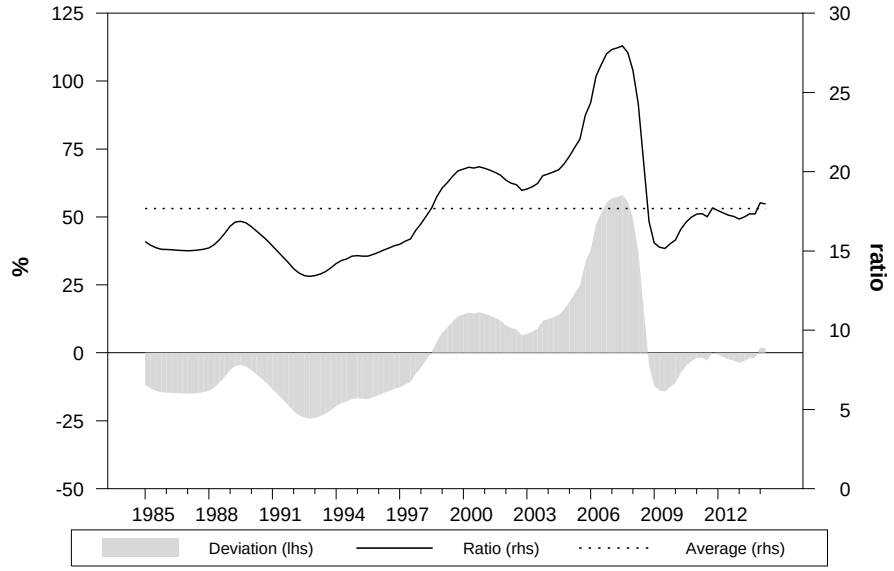

Figure 2: Real commercial property index: prices and rents

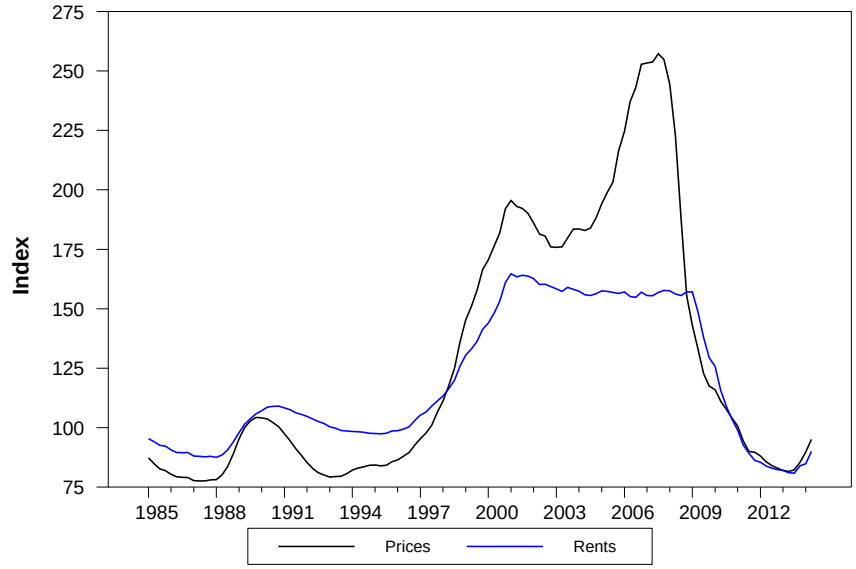

Figure 3: Real commercial property prices and macroeconomic variables

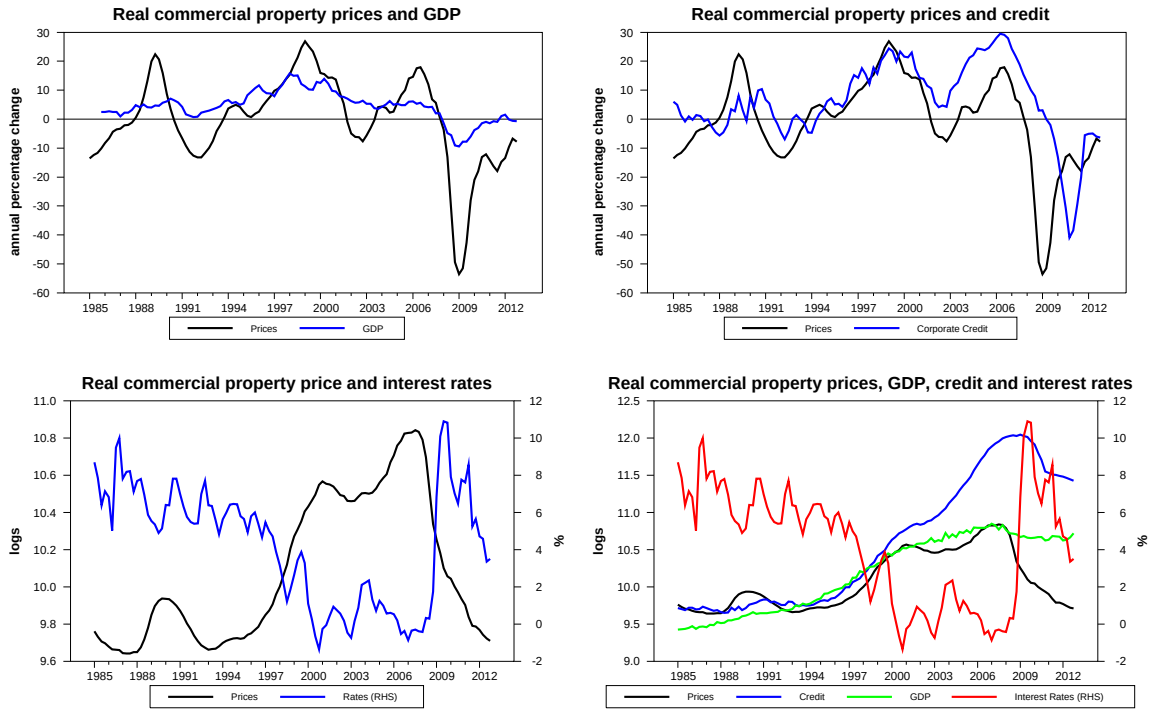

Figure 4: Long-run model of real commercial property prices: 1985Q1-2012Q4

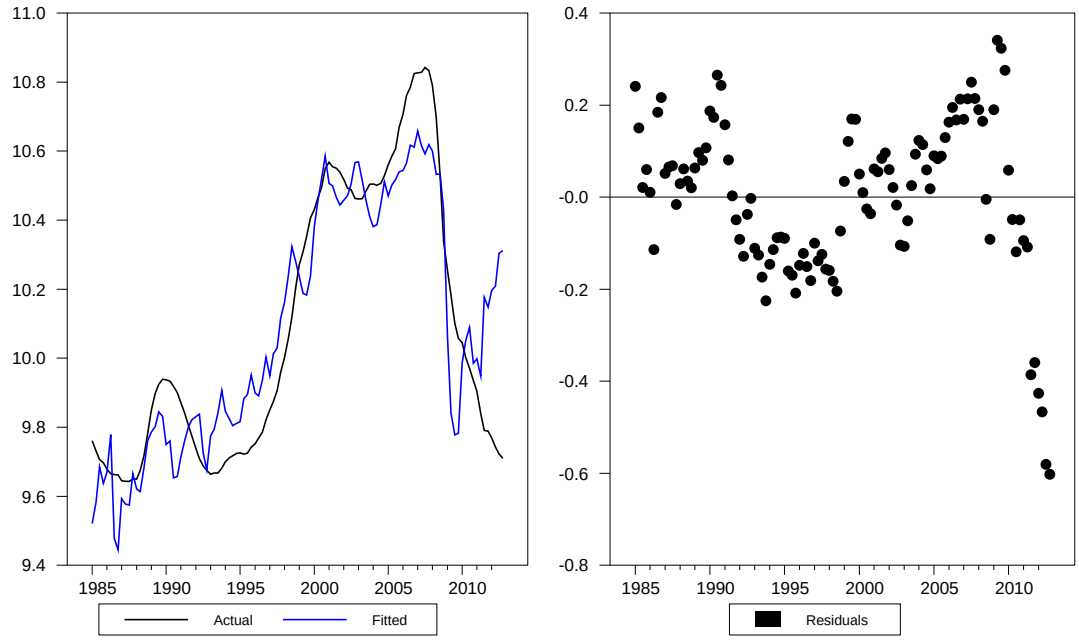

Figure 5: Recursive least squares estimation of GDP and interest rate coefficients with SE bands

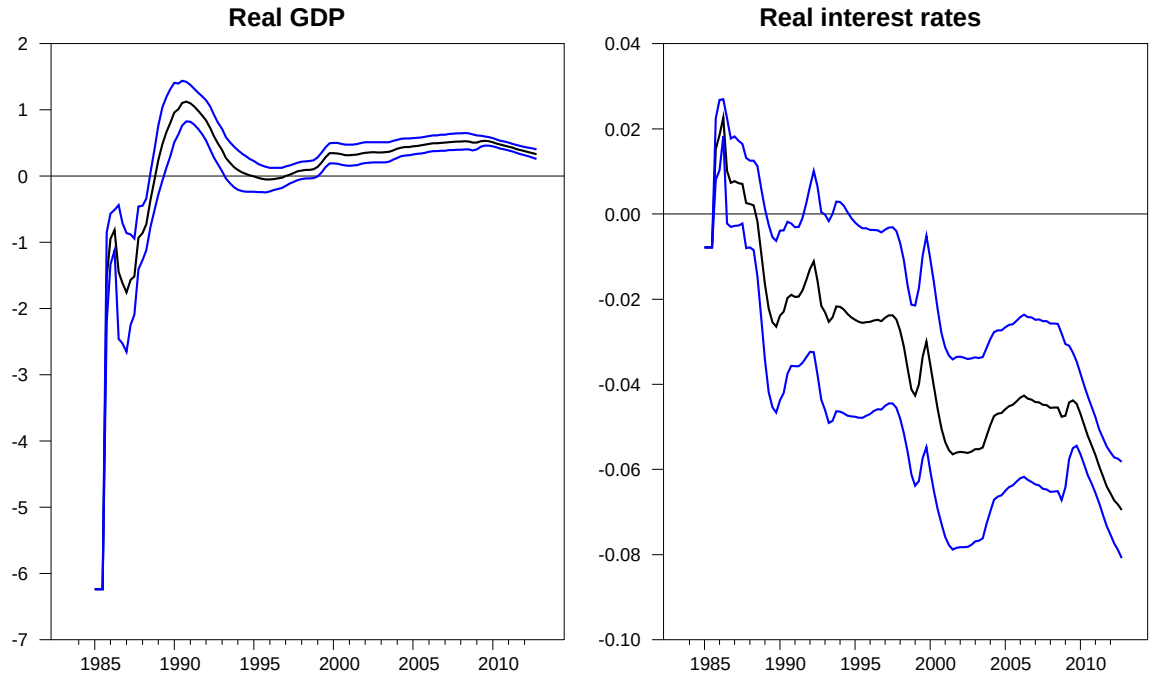

Figure 6: Performance of ECM model 2013:Q1 to 2013Q4

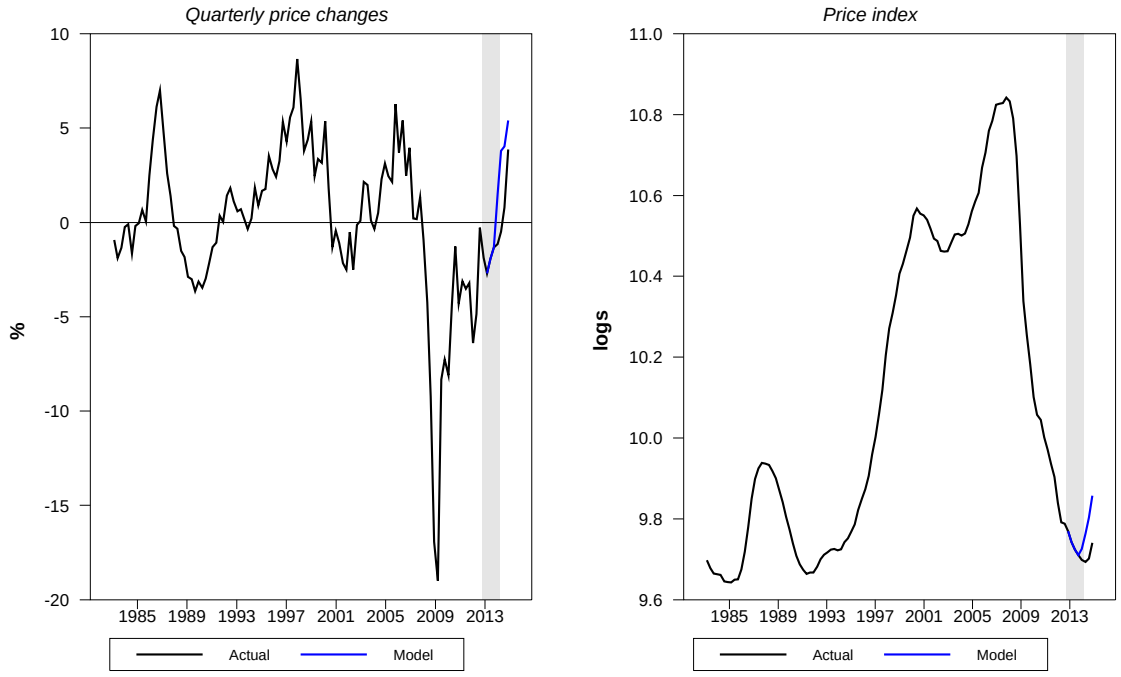

Figure 7: ARDL model of commercial property prices: 1985Q1 to 2012Q4

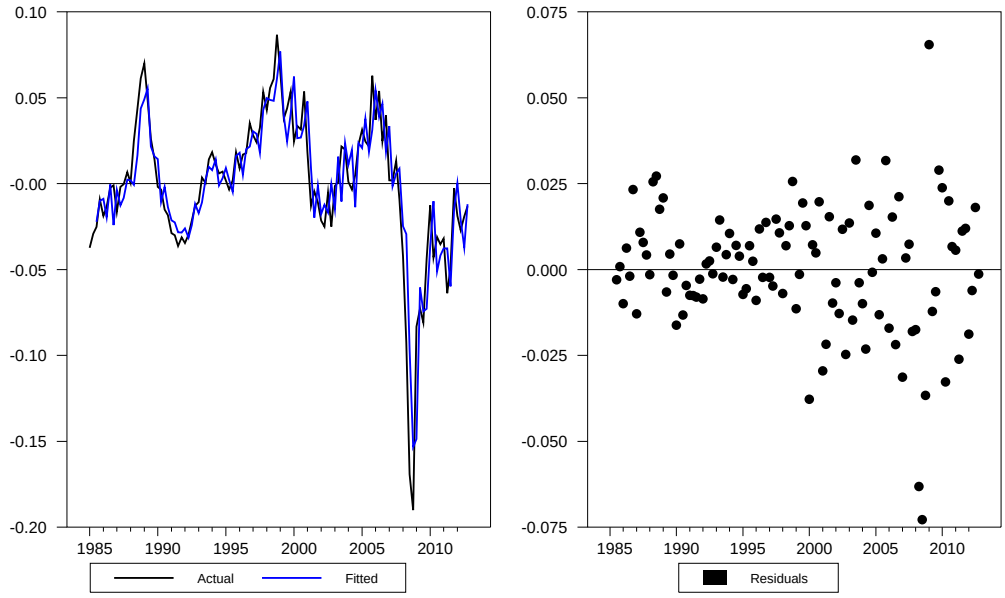

Figure 8: Real commercial property price gap

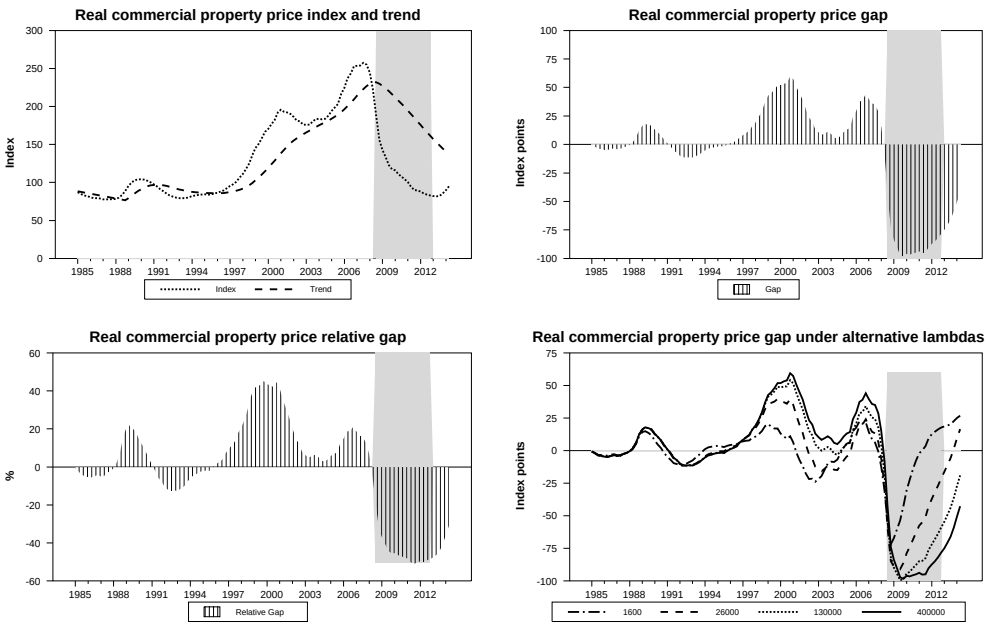

Figure 9: Misalignment in commercial property prices

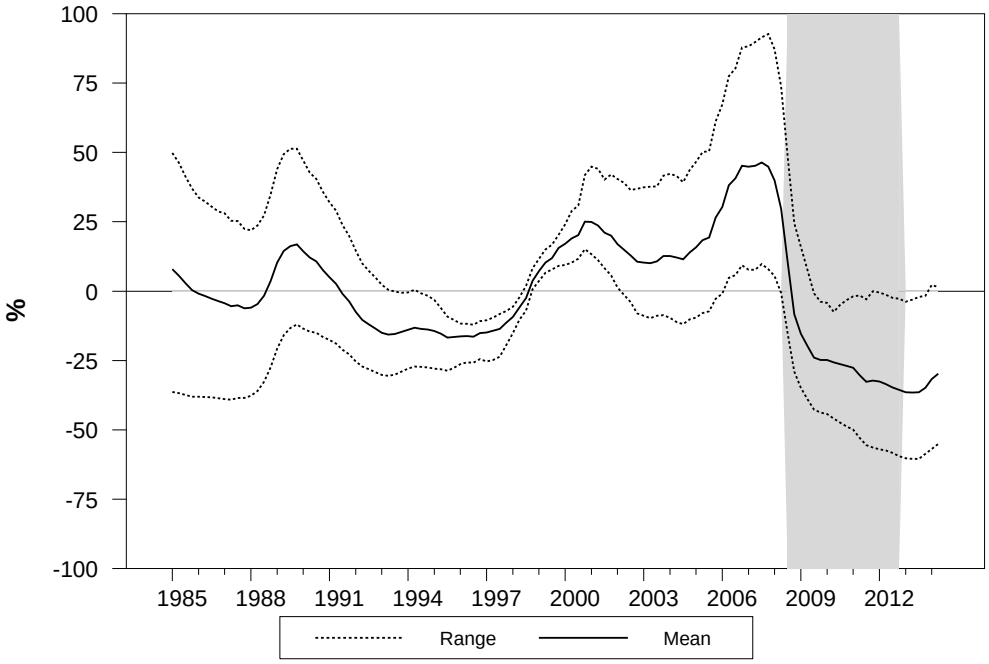

Figure 10: Smoothed probabilities of regime one

Figure 11:Smoothed probabilities of regime one

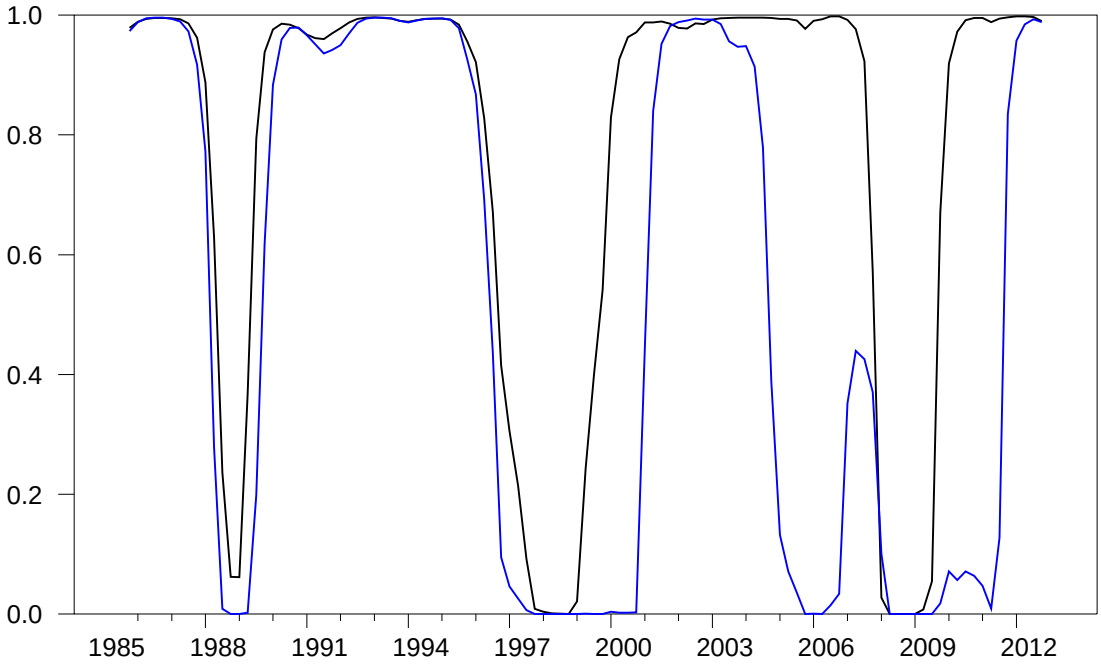

Table 1: Descriptive statistics:1985Q1-2012Q4

Variable	No. of Observations	Mean	Standard Error	Minimum	Maximum
$\triangle cp$	112	-0.1	4.2	-19	8.7
$\triangle cred$	112	1.5	4	-16	8.7
$\triangle gdp$	112	1.2	3.1	-6.3	10.9
$\triangle i$	112	-0.1	1.1	-3.3	5.1
$\triangle rent$	112	0.5	2.6	-8.6	6.3

Note:All variables are in real terms and data are quarterly. Commercial property prices, rent, GDP and corporate credit are in log first differences while interest rates are levels differenced.

Table 2: Unit root testing:1985Q1-2012Q4

Variable	ADF	PP
$\triangle cp_t$	0.02	0.01
$\triangle cred_t$	0.18	0.01
$\triangle gdp_t$	0.21	0.00
$\triangle i_t$	0.00	0.00

Note:The table shows the MacKinnon approximate p-values for the Augmented Dickey-Fuller test and Phillips Perron test for a unit root. Four lags and a constant are included in the regressions. All variables are in real terms. Commercial property prices, GDP and corporate credit are in log first differences while interest rates are levels differenced.

Table 3: Model of Irish real commercial property prices: 1985:Q2 to 2012:Q4

Dependent variable: cp_t		
	OLS	**FM-OLS**
$constant$	6.99	7.57
	(15.07)	(13.11)
gdp_t	0.33	0.28
	(7.62)	(5.17)
i_t	-0.07	-0.08
	(-10.14)	(-9.47)
Bai-Perron Break Point	2009:04	
Dependent variable: $\triangle cp_t$		
ecm_{t-1}	-0.04	
	(-3.27)	
$\triangle cp_{t-1}$	0.87	
	(8.60)	
$\triangle gdp_{t-2}$	0.16	
	(2.31)	
$\triangle i_{t-3}$	0.01	
	(3.29)	
$\overline{R^2}$	0.80	

Note: Absolute t-statistics in brackets. Short-run model estimated using heteroscedasticity-consistent standard errors.

Table 4: Autoregressive Distributed Lag model of commercial property prices:1985Q2 to 2012Q4

Dependent variable: $\triangle lcp_t$	
variable	*Coefficient (t statistics)*
$constant$	-0.004
	(-2.22)
$\triangle lcp_{t-1}$	0.96
	(6.11)
$\triangle lcp_{t-2}$	-0.25
	(-2.19)
$\triangle lrcred_t$	0.14
	(2.07)
$\triangle gdp_{t-2}$	0.19
	(2.40)
$\triangle i_{t-1}$	-0.004
	(-2.56)
$\overline{R^2}$	0.80

Note: Data are quarterly and in real terms. Heteroscedasticity consistent standard errors used

Table 5: General Regime Switching model of Irish commercial property prices:1985Q4 to 2012Q4

	Various estimates of b_t		
	ECM	*ARDL*	*Statistical*
$\beta_{s,0}$	-0.58	-2.53	-0.04
	(-2.00)	(-6.61)	(-0.14)
$\beta_{c,0}$	1.02	-15.13	0.18
	(1.21)	(-8.60)	(0.11)
$\beta_{s,b}$	-0.01	0.53	0.06
	(-0.66)	(9.54)	(4.04)
$\beta_{c,b}$	-0.10	1.23	-0.16
	(-1.77)	(7.43)	(-2.29)
$P(S,S)$	0.94	0.98	0.96
	(26.07)	(44.17)	(64.95)
$P(S,C)$	0.08	0.15	0.15
	(1.79)	(1.95)	(1.58)

Note: Dependent variable is change in quarterly log commercial property prices. Absolute t-statistics are in brackets. Survival regime s is the low volatility period. P(S, C) is the prob. of moving from regime C to regime S

Table 6: Testing the restrictions imposed by the fads models

	ECM	*ARDL*	*Statistical*
	p-values for Wald Test		
$H0: \beta_{s,0} = \beta_{c,0}$	0.08	0.00	0.90
$H0: \beta_{c,b} = \beta_{c,b}$	0.12	0.00	0.00
	p-values for Likelihood Ratio Test		
H0:Restrictions are valid	0.31	0.00	0.00